Journal of Athletic Training 2009;44(2):160–164

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original research

A Clinical Method for Identifying Scapular Dyskinesis, Part 1: Reliability

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Context: Shoulder injuries are common in athletes involved in overhead sports, and scapular dyskinesis is believed to be one causative factor in these injuries. Many authors assert that abnormal scapular motion, so-called *dyskinesis*, is related to shoulder injury, but evidence from 3-dimensional measurement studies regarding this relationship is mixed. Reliable and valid clinical methods for detecting scapular dyskinesis are lacking.

Objective: To determine the interrater reliability of a new test designed to detect abnormal scapular motion.

Design: Correlation design using ratings from multiple pairs of testers.

Setting: University athletic training facilities.

Patients or Other Participants: A sample of 142 athletes (from National Collegiate Athletic Association Divisions I and III) participating in sports requiring intense overhead arm use.

Intervention(s): Participants were videotaped from the posterior aspect while performing 5 repetitions of bilateral, weighted (1.4-kg [3-lb] or 2.3-kg [5-lb]) shoulder flexion and frontal-plane abduction. Videotapes from randomly chosen participants were subsequently viewed and independently rated for the presence of scapular dyskinesis by 6 raters (3 pairs), with each pair rating 30 different participants. Raters were trained to detect scapular dyskinesis using a self-instructional format with standardized operational definitions and videotaped examples of normal and abnormal motion.

Main Outcome Measure(s): Scapular dyskinesis was defined as the presence of either winging or dysrhythmia. Right and left sides were rated independently as normal, subtle, or obvious dyskinesis. We calculated percentage of agreement and weighted kappa (κ_w) coefficients to determine reliability.

Results: Percentage of agreement was between 75% and 82%, and κ_w ranged from 0.48 to 0.61.

Conclusions: The test for scapular dyskinesis showed satisfactory reliability for clinical use in a sample of overhead athletes known to be at increased risk for shoulder symptoms.

Key Words: shoulder, upper extremity, kinematics, assessment

Key Points

- Trained athletic trainers and physical therapists can recognize and distinguish between abnormal scapular movement patterns and normal patterns in young, athletically active adults.
- The scapular dyskinesis test provides a reliable method for clinical examination of overhead athletes.

Visible alterations in scapular position and motion patterns have been termed *scapular dyskinesis*[1] and are believed to occur as a result of changes in activation of the scapular stabilizing muscles[2]; damage to the long thoracic, dorsal scapular, or spinal accessory nerves; or possibly reduced pectoralis minor muscle length.[3] Scapular dyskinesis has been associated with shoulder injury, and several groups have found differences in scapular kinematics among people with instability, rotator cuff tears, and impingement syndrome when compared with healthy shoulders, although the magnitude of differences between symptomatic and asymptomatic individuals is typically very small.[1,2,4–6] Visually, findings of dyskinesis have been reported as winging or asymmetry.[1] To develop definitive conclusions about the role of scapular kinematics in those with shoulder injury and to identify a potential subset related to abnormal scapular motion patterns, clinical methods to distinguish normal and abnormal scapular motion are needed.

Although assessing the scapulothoracic articulation is considered an essential component of the shoulder evaluation, clinical assessment of scapular motion has proven challenging because of both the extensive soft tissue covering the scapula and the complex 3-dimensional (3-D) patterns of motion that occur with shoulder use. Abnormal scapular mechanics are present among some persons with subacromial impingement and shoulder instability, yet a validated, clinically feasible method of identifying scapular dysfunction is lacking.[1,4,7]

Clinical measures of scapular position based on side-to-side differences of linear measures (from the spine to the medial border of the scapula) have lacked reliability,[8,9] and measures of linear asymmetry in athletes may not indicate dysfunction.[10] Additionally, linear measures taken at static arm positions fail to capture the 3-D motion patterns present during dynamic upper extremity movement, as in overhead occupational activity or sports. Warner et al[1] found that scapular abnormalities were more evident during dynamic assessment than during static testing in participants with impingement and instability. Kibler[11] suggested that mild scapular dyskinesis is more frequently evident during the lowering phase of arm movement, presumably because of the altered neuromuscular control required during eccentric muscle contraction. Visual assessment offers an alternative to linear measures for evaluating 3-D scapular motion in a practical clinical method that incorporates dynamic upper extremity tasks that require both raising (concentric) and lowering (eccentric) phases.

Kibler et al[12] reported the reliability of a visually based classification system for scapular dysfunction that defined 3 different types of motion abnormalities: type 1 = inferior angle prominence, type II = medial border prominence, and type III = excessive superior border elevation. Normal, symmetric scapular motion was considered type IV. Volunteers (n = 26) were videotaped from behind during arm elevation in the frontal and scapular planes. The videotapes were viewed and rated by 2 physicians and 2 physical therapists. Kappa coefficients were 0.42 and 0.31 for interrater reliability between the 2 physical therapists and the 2 physicians, respectively, which are rather low to support the use of their system. However, the authors suggested that with refinement, reliable visual analysis of scapular dysfunction may be possible.

Without a clinically feasible, reliable method of determining the presence of scapular dyskinesis, clinicians have no way of identifying which patients need interventions targeted at scapular control. Similarly, researchers trying to understand the relationship between scapular dyskinesis and shoulder injury would benefit from a simple method of identifying those with dyskinesis. The purpose of our study was to determine the interrater reliability of a newly developed scapular dyskinesis test (SDT) that is visually based and uses dynamic, loaded tasks.

METHODS

We used a single-session measurement design with multiple rater assessments, both in real time and with videotaped segments viewed at a later date. A total of 142 athletes competing in a National Collegiate Athletic Association sport that required repetitive overhead activity were recruited for this study. This population was selected because of the high incidence of shoulder injury reported among athletes participating in sports requiring overhead use of the arm.[13–16] The athletes' sports included water polo (n = 89), swimming (n = 19), baseball/softball (n = 28), and other (eg, volleyball, tennis; n = 6). Thirty-one athletes were females and 111 were males, with 93 competing at the Division I level and 49 at the Division III level. Study participants were required to complete all test movements to be included in the study. Exclusion criteria were a current pain rating of 7/10 or greater on a numeric rating scale where 0 represents *no pain* and 10 represents *the worst pain possible*; a history of rotator cuff or glenoid labral tear; shoulder dislocation, fracture, or shoulder surgery within the past year; history of direct contact injury to the neck or upper extremities within the past 30 days; allergy to adhesives; or body mass index ≥ 30.0. Before testing, all volunteers signed a consent form approved by the Arcadia University and Temple University institutional review boards, which also approved the study.

Instrumentation

Two video cameras (model 8 DCR-TRV730; Sony Corp of America, San Diego, CA) were used to videotape participants and play back the recorded segments. Volunteers stood 2 to 3 m from the camera, depending on their height, and were videotaped from both superior and posterior views. An extension arm was attached to the camera stand to obtain the superior view, and the mounting points were marked in order to maintain a consistent setup throughout the data collection process. However, after viewing several participants, we judged the superior view unnecessary and only used the posterior view in the final assessment (Figure 1).

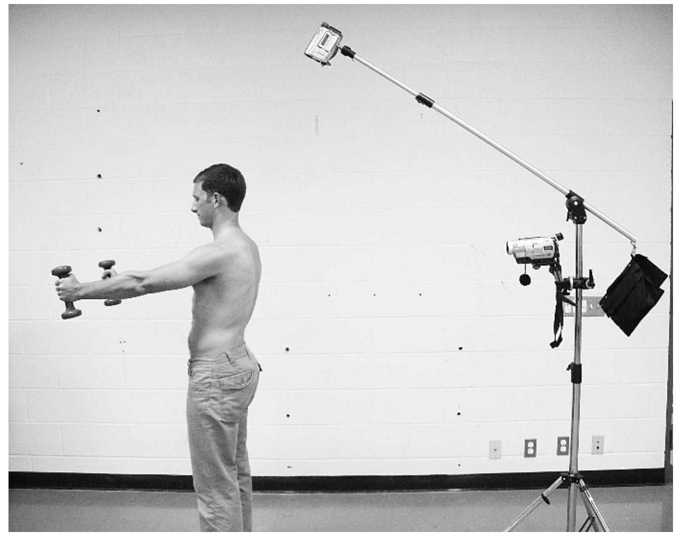

Figure 1. Set-up of participant and cameras for videotaping.

Investigators adjusted the camera's lens so that the posterior view included each volunteer's waist, head, and elbows through the full range of motion. For the superior view, the camera was adjusted to include the posterior buttocks to the anterior aspect of the scalp without any part of the face visible.

Experimental Procedure

Male participants were asked to remove their shirts and females were asked to wear halter tops during the study to allow observation of the posterior thorax. After completing demographic and self-report measures, volunteers underwent a physical examination by a certified athletic trainer, including special tests, range of motion, and isometric strength measures. In addition to these tests, each participant performed 5 repetitions of bilateral, active, weighted shoulder flexion and bilateral, active, weighted shoulder abduction (frontal plane) while they were videotaped from the posterior and superior views. These 2 weighted elevation tests constituted the tasks for the SDT.

After the tester demonstrated the movements, the volunteers were instructed and briefly practiced each movement. Testing began with arms at the side of the body, elbows straight, and shoulders in neutral rotation; 2 testers observed from the back, 2 to 3 m away. Participants were asked to simultaneously elevate their arms overhead as far as possible to a 3-second count using the "thumbs-up" position and then lower to a 3-second count. Tests were performed with volunteers grasping dumbbells according to body weight, 1.4 kg (3 lb) for those weighing less than 68.1 kg (150 lb) and 2.3 kg (5 lb) for those weighing 68.1 kg or more. These weights were chosen

Table 1. Scapular Dyskinesis Test: Operational Definitions and Rating Scale

Operational Definitions

Normal scapulohumeral rhythm: The scapula is stable with minimal motion during the initial 30° to 60° of humerothoracic elevation, then smoothly and continuously rotates upward during elevation and smoothly and continuously rotates downward during humeral lowering. No evidence of winging is present.

Scapular dyskinesis: Either or both of the following motion abnormalities may be present.

Dysrhythmia: The scapula demonstrates premature or excessive elevation or protraction, nonsmooth or stuttering motion during arm elevation or lowering, or rapid downward rotation during arm lowering.

Winging: The medial border and/or inferior angle of the scapula are posteriorly displaced away from the posterior thorax.

Rating Scale

Each test movement (flexion and abduction) rated as

a) *Normal motion:* no evidence of abnormality

b) *Subtle abnormality:* mild or questionable evidence of abnormality, not consistently present

c) *Obvious abnormality:* striking, clearly apparent abnormality, evident on at least 3/5 trials (dysrhythmias or winging of 1 in [2.54 cm] or greater displacement of scapula from thorax)

Final rating is based on combined flexion and abduction test movements.

Normal: Both test motions are rated as normal or 1 motion is rated as normal and the other as having subtle abnormality.

Subtle abnormality: Both flexion and abduction are rated as having subtle abnormalities.

Obvious abnormality: Either flexion or abduction is rated as having obvious abnormality.

based on pilot data indicating that athletes, including those with mild to moderate symptoms, can repetitively lift these amounts through their full available range of motion. Test movements were based on the findings of a pilot study[17] and Johnson[18] that showed active movements with resistance more often resulted in abnormal scapular motion than static tests in those with shoulder injury.

All examiners underwent standardized training via a self-instructional slide presentation including operational definitions, photographs, and embedded video examples (http://www.arcadia.edu/academic/default.aspx?id515080). The written operational definitions and rating scale used for training are shown in Table 1, and representative volunteers are shown in Figure 2. To enhance the generalizability of our findings, we deliberately did not provide individual training. Visual ratings were determined at the time of testing and also at a later time by viewing video recordings. For the "live" rating, 2 of the 5 investigators (a certified athletic trainer and a licensed physical therapist or physical therapy student) observed and independently rated the athletes at the time of testing, but they often became aware of the judgments of the other raters. Therefore, it was possible for the investigators to learn the tendencies of other raters during the study. At a later time, 6 raters who were not investigators (3 separate pairs consisting of 2 certified athletic trainers with 1–2 years' experience and 4 licensed physical therapists with 7–20 years' experience) independently viewed randomly selected videotaped athletes (n = 90; ie, 30 different participants for each pair) on a large screen. Raters were permitted to view a test movement for a second time, if requested, in order to simulate a clinical situation in which a therapist could ask a patient to repeat a motion. Each rater then independently rated the test movements for each shoulder as having normal motion, subtle dyskinesis, or obvious dyskinesis. No discussion was permitted until all videos were rated.

Data Analysis

Interrater reliability for the SDT was described using percentage of agreement and weighted κ (linear weighting) based on 3 possible ratings from the flexion and abduction test movements: normal, subtle, or obvious. The ratings of flexion and abduction motions were combined such that if both motions were rated normal or 1 was judged normal and the other, subtle dyskinesis, the final rating was normal; if both were judged as subtle dyskinesis, the final rating was subtle dyskinesis; and if either test motion was rated obvious dyskinesis, the rating was obvious dyskinesis. Percentage of agreement and weighted κ were calculated among the live raters for all 142 participants and for the 3 pairs of videotape raters viewing 30 participants each. Additionally, because the κ statistic can be artificially low with inadequate variation in the data, the maximum κ possible was calculated as suggested by Sim and Wright.[19] To avoid violating the assumption of independence, reliabilities for the left and right sides were calculated separately. Data related to special tests, range of motion, and strength were not considered in the analysis of this study.

RESULTS

The percentage of agreement and κ coefficients for the SDT for both the live ratings and the videotaped ratings are shown in Table 2, along with the maximum possible κ value for the given data. Maximum κ values were reported since they "gauge the strength of agreement while preserving the proportions of positive ratings demonstrated by each clinician"[19] and, therefore, may provide a more meaningful reference value. The agreement among live ratings by the investigators was slightly higher than among the raters viewing the videotaped athletes.

DISCUSSION

We found moderate interrater reliability (average κ_w = 0.57 for live raters and 0.54 for those viewing videotape) in classifying scapular motion as normal, subtle dyskinesis, or obvious dyskinesis.[20] These results are better than those reported by Kibler et al,[12] who also used a visually based system and reported κ coefficients of 0.42 and 0.32 for interrater reliability among physical therapists and physicians. Our system did not attempt to distinguish among subtypes of dyskinesis, as we believe that the subtypes defined by Kibler et al are not mutually exclusive categories and often occur simultaneously. Kibler et al[12] required a single forced choice among 4 categories, including 3 subtypes of dyskinesis: type 1 = inferior angle prominence,

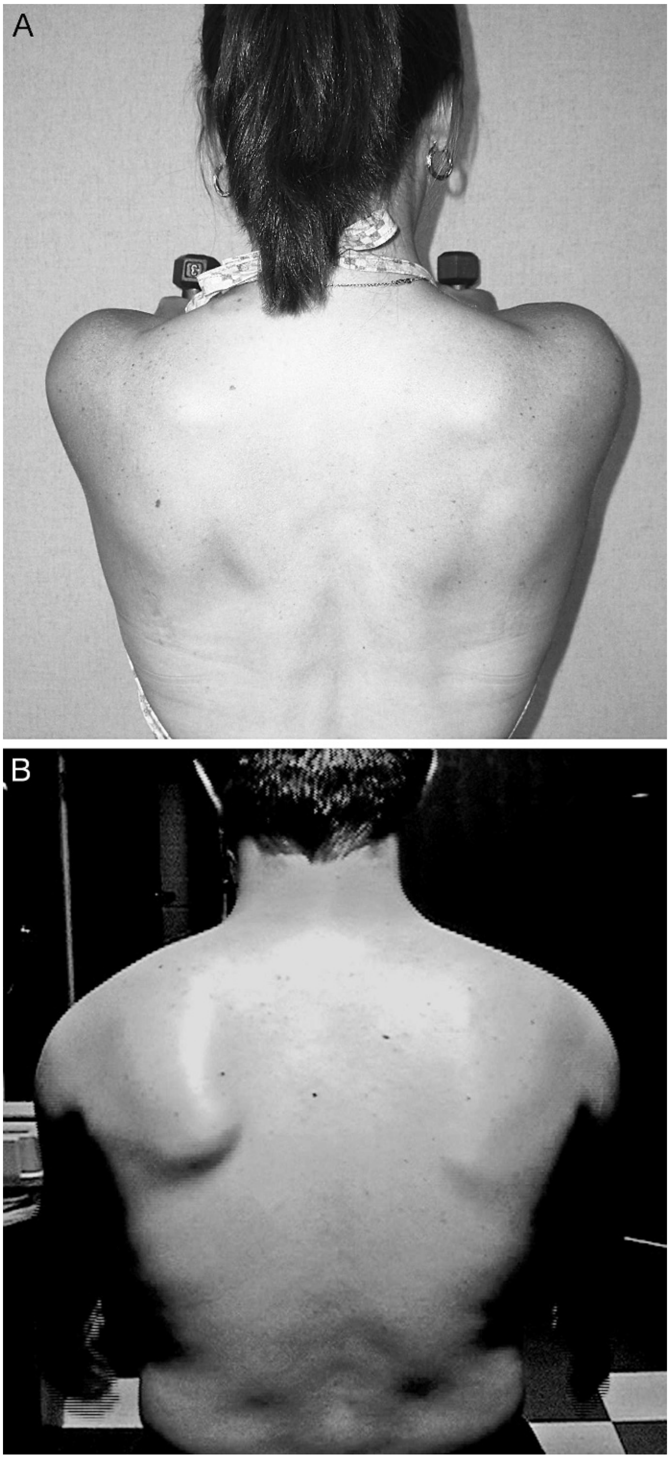

Figure 2. Participants performing flexion with dumbbell. A, The scapular motion pattern was rated as normal. B, The scapular motion pattern was rated as having obvious dyskinesis on the left and subtle dyskinesis on the right.

type II = medial border prominence, type III = excessive superior border elevation, and type IV = symmetric scapular motion (normal). Their method seemed to focus on detecting asymmetric motion patterns, although their descriptions of dyskinesis did not seem to demand asymmetry and may have led to rater confusion. In our study, raters were instructed to rate each scapula independently of the other side. In a study of 71 collegiate athletes who participated in 1-arm–dominant sports, Koslow et al[10] found that 52 exhibited a difference of at least 1.5 cm on 1 or more of the 3 positions assessed for the lateral scapular slide test. They concluded that measures of asymmetry in athletes do not indicate dysfunction. Our raters were instructed not to focus on side-to-side comparisons but rather on absolute scapular position and motion relative to the thorax. They identified participants with both unilateral and bilateral abnormalities, primarily winging. Of the 142 volunteers rated, 52 had obvious dyskinesis on the left, 37 had obvious dyskinesis on the right, and 32 had obvious dyskinesis bilaterally. This provides further evidence that the rating of dyskinesis should not be based on measures of asymmetry, as suggested by others.[11,12] We also believe that standardized training using videotaped examples of normal and abnormal motion was an important feature of this study and improved reliability. Using only written descriptions to define a dynamic motion abnormality is inherently limiting; therefore, we used videotaped examples to help further define normal and abnormal motion.

We determined a single rating based on observation of flexion and abduction tasks and allowed observation of either dysrhythmia or winging to identify dyskinesis. We believe this simplified approach is appropriate because the primary treatment decision is simply whether or not to address scapular dyskinesis in a treatment program with scapular exercises and other strategies such as taping or bracing. Our current approach to treating scapular dyskinesis does not vary based on the specific type of dysfunction (dysrhythmia or winging) or affected test motion (flexion or abduction).

Our method also included loaded tasks, which have been shown to alter scapular kinematics.[1,5,21–23] Muscular fatigue may directly affect scapulohumeral rhythm, resulting in compensatory increased rotation or destabilization of the scapula,[23] which suggests the need to assess conditions when resistance to the arm is applied. Although preliminary testing with this classification system involved active and resisted movements,[17] we retained only the weighted tests, as they most frequently provoked abnormal motion and were thought to better reproduce daily activities of workers, homemakers, and athletes. More specifically, weighted flexion was the motion that most commonly resulted in dyskinesis. At least 1 rater observed obvious dyskinesis in 45 left shoulders and 46 right shoulders of 142 participants (284 shoulders) rated visually at the time of testing during weighted flexion. For weighted abduction, at least 1 rater observed obvious dyskinesis in 29 left shoulders and 25 right shoulders.

CONCLUSIONS

Taken collectively, our findings suggest that abnormal scapular movement patterns in young, athletically active adults can be visually recognized and distinguished from normal patterns with satisfactory reliability by trained athletic trainers and physical therapists using the SDT. The test represents a reliable and feasible method for clinical examination of overhead athletes, and the reliability was better than that for a previously described visual classification system.[12] Although we believe this system would most likely also prove reliable in a clinical setting with patients seeking medical care, the SDT should be studied with this population in the future.

Table 2. Interrater Reliability of the Scapular Dyskinesis Test

Shoulder	Live or Videotape Rating	Raters	Percentage of Agreement	κ_w	95% Confidence Interval	Maximum κ Possible
Right (n = 90)	Videotape	3 Rater pairs	82	0.61	0.43, 0.78	0.79
Left (n = 90)	Videotaped	3 Rater pairs	75	0.48	0.29, 0.67	0.79
Right (n = 142)	Live	All	80	0.55	0.32, 0.78	0.93
Left (n = 142)	Live	All	81	0.58	0.38, 0.79	0.75

ACKNOWLEDGMENTS

This study was funded by a grant from the National Athletic Trainers' Association Research and Education Foundation. We also thank Ann Barr, PT, PhD, and Mary Barbe, PhD, for their helpful insight into the design of the study and Villanova University Water Polo Head Coach Dan Sharadin for assistance with recruitment.

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